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DISEASES OF POTATOES IN IOWA¹

I. E. MELHUS, D. R. SHEPHERD AND MARIE A. CORKLE

It is a well known fact that potato production in Iowa has decreased since 1895. This raises the question as to the cause of this decline. Many factors contributed to the decrease in potato production, one of which was the destructiveness of various diseases. Many diseases tend to initiate sharp fluctuations in yield and quality, two factors that have much to do with the stability of a given crop. Previous to 1895 there were no well developed control measures for any of the potato diseases: in fact the causal agencies of many of them were quite unknown. Consequently, as different pathogens became established in the virgin soil they accentuated the annual fluctuation in production. The decline following 1895 warrants study particularly from the viewpoint of the role of diseases. In order to do this all available records of potato failures and diseases have been consulted and summarized in the following pages.

Diseases of the potato crop were referred to in some of the earliest Iowa agricultural records. These early reports probably were due to the fact that potatoes were one of the earliest crops planted following the breaking of the prairie. According to the Iowa Historical and Comparative Census, 1836 to 1880, and the United States Census, 1855 to 1935, in 1855 only 18,124 acres were planted in potatoes in Iowa. The acreage increased gradually until about 1895 when there were 170,285 acres. From that time on it gradually decreased until 1930, when there were only 44,666 acres. The yield tendency from 1865 to 1925 was gradually downward (fig. 1) while the price tendency from 1865 to 1925 was generally upward (fig. 2).

In 1919 Melhus and Gilman (21) emphasized the importance of potato diseases when they wrote as follows: "Half of the seed potatoes planted each spring are infected with some organism that causes disease. Black leg, black scurf, common scab and dry rots are the most common of these diseases. They reduce the stand, injure the roots, mar the tubers and reduce the yield."

Most of Iowa's commercial seed potatoes are shipped in from the north largely because it is impossible to grow disease-free seed potatoes in this state. Some success has been attained using

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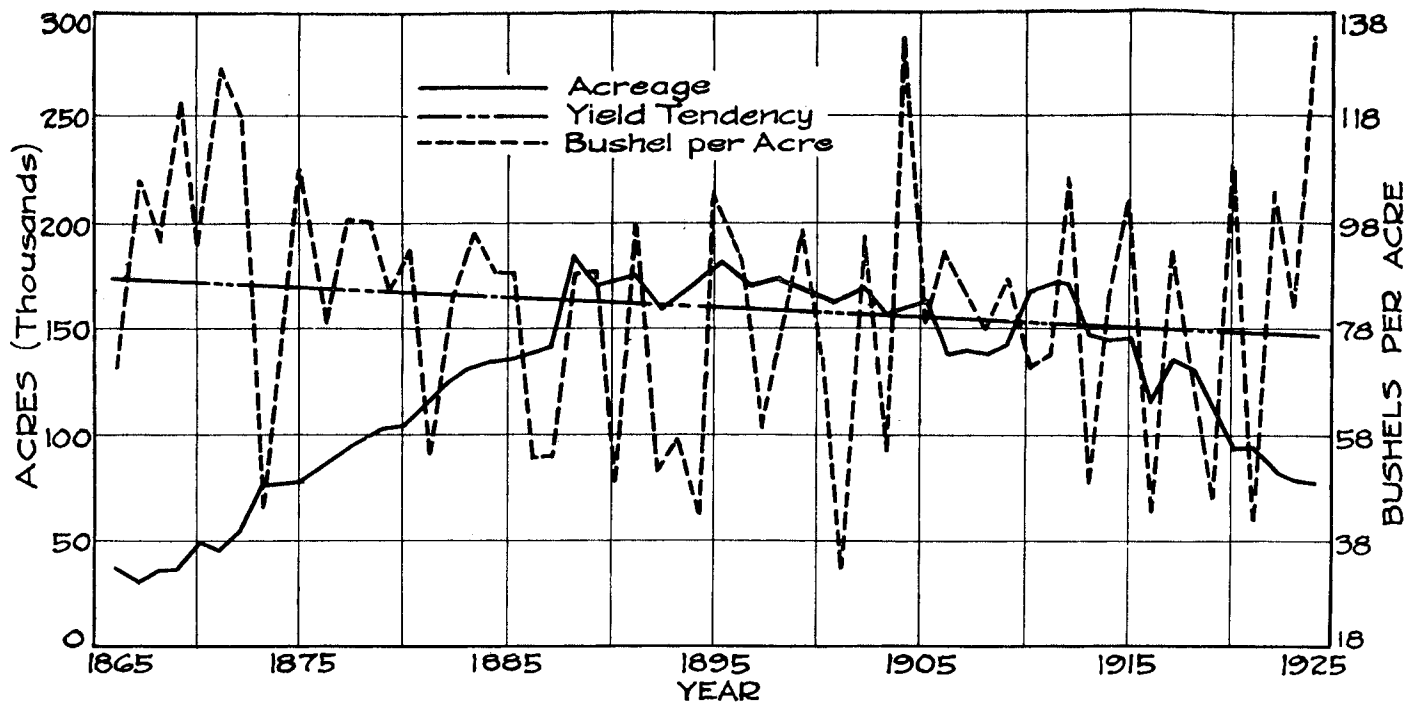


Figure 1. The yield tendency of potatoes in Iowa declined after 1865. The wide fluctuations in yield probably in a large part were caused by potato diseases.

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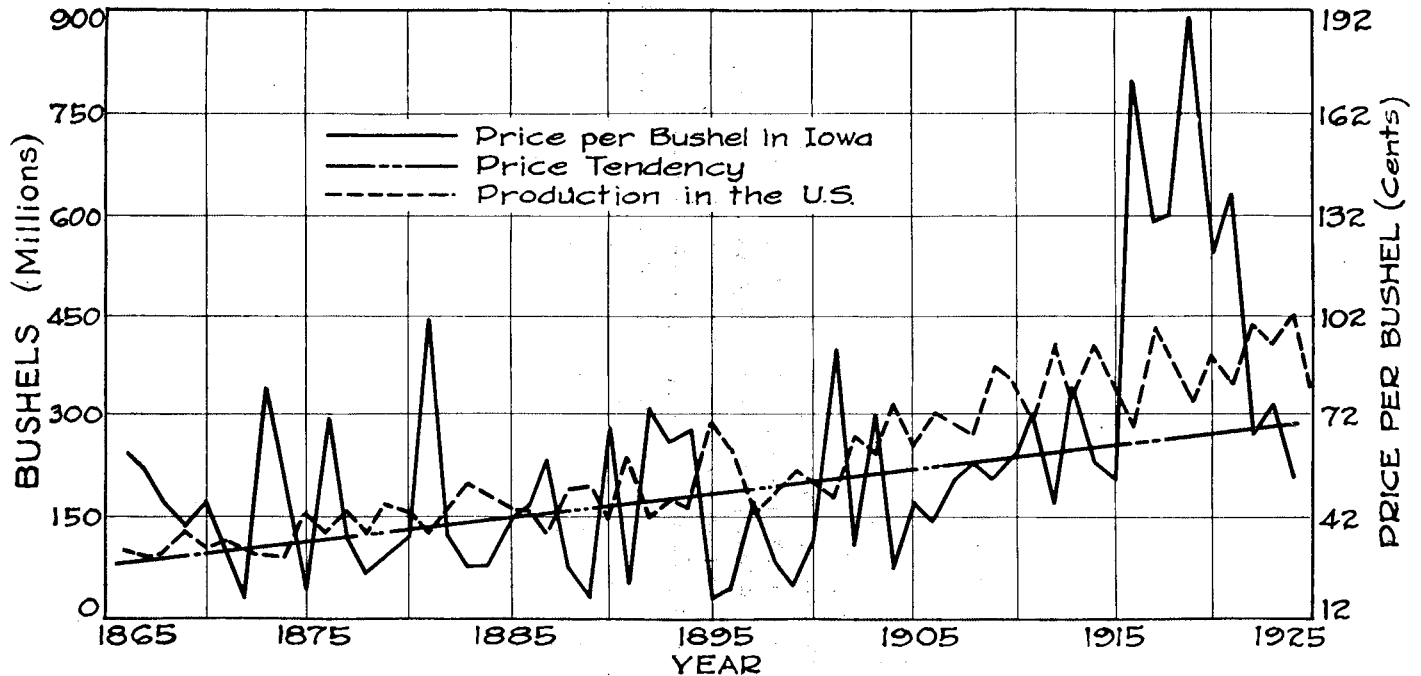


Figure 2. The price tendency of potatoes has been steadily upward in Iowa since 1865.

the Iowa grown crop one year from imported seed; after that, however, there is a marked reduction in yield. In Iowa the symptoms of certain virus diseases are masked at high temperatures; consequently, it has been impossible to certify Iowa seed potatoes.

LATE BLIGHT OF POTATOES

One of the earliest diseases of potatoes reported was late blight, which, it is interesting to note, has occurred many times but only occasionally in destructive form. Serious losses from rot were reported in 1858 (2, p. 339), 1865 (3, p. 305, 347, 369), and 1866 (4, p. 292). Ten counties reported serious rot losses in 1869 (5, p. 290, 328, 329) and the crop in 11 counties suffered from the rot in 1876 (6, p. 312). That the trouble was general throughout the state is made evident by the fact that the reports came from such widely scattered counties as Page, Kossuth, Winneshiek, Scott and Wapello. It is not known what organism may have caused the widespread losses from rot during those early years although the condition described inadequately in the popular press suggests late blight caused by *Phytophthora infestans*. (Mont.) deBy. This disease was referred to specifically for the first time in 1885 when it was reported (20, p. 95) as being severe throughout the entire state. Halsted called attention to the presence of *P. infestans* in Iowa in 1885—"There was much complaint of rot in all parts of the state and tubers from the college gardens and root houses contained the parasite in abundance. The potato crop for the present year (1887) has been very light and no rot was observed."

In some old manuscripts (24) found in 1933 in the Botany Department of the University of Tennessee there was an early history of late blight in the United States. In this paper a loss of 18 percent caused by late blight was reported for Iowa in 1885. Climatological records for 1885 (table 1) show that the rainfall in June, July and August was in excess, and the rainfall in September slightly deficient. Subnormal temperatures were very pronounced for the growing season with the exception of certain days of July, when the temperature was slightly above normal.

In this early history the disease was reported with a loss of 6 percent again in Iowa in 1886. September in this year was comparatively wet and cool, but the months of June, July and August were very dry and warm. The occurrence of late blight in

this year might be due either to local incidence of the disease where the rainfall was abundant and the temperature subnormal or to the carrying over of the pathogen by the infected seed piece from the previous year's outbreak (1885) or both.

Considerable damage was caused by the late blight organism in 1903. A press bulletin issued by Pammel (23) July 6, 1903, reads as follows: "In making an examination of some potato plants a few days ago, I found that a large percentage of the leaves were affected by the common potato rot fungus, *Phytophthora infestans*. This fungus to my knowledge has not been found in this state for quite a number of years. The present attack of potatoes and the severity seem to indicate that we have had an unusual season. The matter is of such importance to potato growers that they should be made familiar with methods of exterminating the fungus."

Late blight was reported from 11 counties in Iowa in 1905 (13), however, the disease as a whole was not serious. The temperature was subnormal in July and above normal in June, August and September. The rainfall was slightly in excess in August and was deficient in June, July and September. Weather conditions during this year may have been too variable for an epiphytotic of late blight.

In 1915 late blight was prevalent in all parts of Iowa and heavy losses were reported. The temperature throughout June, July and August was subnormal. Erwin (18) stated that July of 1915 was very wet. The rainfall in August was slightly deficient, but it was in excess during the other three months. The prevalence of this disease apparently was favored by the cool and wet season.

There has been no serious epiphytotic of late blight in Iowa since 1915, although the disease has occurred frequently since that time in the north central potato growing section of Iowa, especially in Mitchell County. The disease was collected in Mitchell County in 1917, but the damage was slight. In the same area, however, late blight was destructive in 1918, when 10 to 20 percent of the tubers rotted. In a survey made in 1918 by E. H. Toole (25) the disease was found as far west as Hancock County, east to Allamakee County and south as far as Fayette and Bremer Counties. Infection was general and severe throughout the area covered where the fields were frequent. It was only slight where the fields were scattered.

In 1924 there was again some loss by late blight in Dubuque and Mitchell Counties according to Porter (16). Rotting occurred on tubers in storage at Osage and Bernard. The temperature was subnormal throughout the whole growing season and the rainfall was in excess in June and very abundant in August. The development of the disease was again favored by this ideal cool and wet weather condition.

Burns (13) reported a trace of late blight in 1925, but this is doubtful. In 1928 Porter (13) reported late blight again in the northern and northeastern part of the state. He recorded high humidity and cool nights in August and September. The rainfall in August was indeed very abundant and the temperature only slightly above normal in this section of the state.

This disease was collected in 1939 by Waldee at Osage and identified by Melhus (7, p. 149). It was not prevalent in the state and was collected only at Osage. The rainfall was above normal in June and high in August.

Erwin (18) found that severe outbreaks of late blight in Iowa have occurred during years of high humidity, heavy dews and low midsummer temperatures. This suggests the possibility that the widespread losses sustained from tuber rot in the early days may have been caused by this fungus. Weather conditions for 1876, a year when rot losses were widespread over the state, are quite comparable to those of 1885, 1903 and 1915, the years when late blight was known to have been severe.

By referring to the moisture and temperature data presented in table 1, one finds that each year when late blight was collected in the state the temperature, with a few exceptions, was either subnormal or normal during the growing season. In each case the above normal temperature was very slight. On the other hand, in the years when late blight has been known to occur, rainfall shows much greater fluctuation above and below normal. For instance, in 1885 there were over five inches of rainfall in June, four in July, above five in August and about three in September. In 1903 the rainfall was subnormal in June and September but above normal in July and August. Rainfall was above normal in 1915, except in August, when it was a bit below normal. In 1917, July was the only month when the rainfall was above normal. In 1918, the rainfall was above normal in June, July and August, and subnormal in September. In 1924 the rainfall in June was above normal and in August very much above normal (about two inches); September was slightly below

normal. In 1925 June was very wet, with three inches above normal. July and August, on the other hand, were subnormal and September was above normal. It is interesting to note that in 1928 the June rainfall was just below normal, July slightly above, August more than six inches above normal, and September below normal. In 1939 the rainfall was nearly normal for June, subnormal in July, above normal in August, but in September it was three inches below normal.

It is worthy of note that during 1876, 1885, 1903, 1915, 1924, 1925 and 1928, the total rainfall for the growing months was above normal, and in 1886, 1905 and 1939 was below normal.

It is not clear from the weather data shown in this table just why late blight occurred in Iowa in 1939. The temperature and moisture conditions were not so favorable as in other years when late blight occurred in the state. The pathogen may well have spread into Iowa from Wisconsin and Minnesota, where the disease was known to be more prevalent than in this state.

COMMON SCAB

The earliest report of common scab was in 1870 (1, p. 62). In 1894 (22) it was reported as one of the serious diseases of the Iowa potato crop. That year F. S. White wrote as follows: "As yet we are not badly affected in Iowa with potato diseases. The scab is the worst form of disease we have to contend with. No explanation of this disease that I have seen has been satisfactory."

Scab, caused by *Actinomyces scabies* (Thax.) Güssow, occurs wherever potatoes are grown, losses of 5 percent being common. In 1919, 1932 and 1934 the losses ranged from 10 to 20 percent, but generally are less than 10 percent. The practice of using certified seed and the improvement in methods of seed treatment have reduced the losses from common scab. Certified seed cannot carry more than 1 percent of the tubers infected.

In 1918 the practice of treating the seed by the hot formaldehyde method was first introduced in the United States by Melhus and Gilman (21). It made the treatment of seed potatoes readily possible for the large grower, which had not been practical by the cold, longtime methods.

The most significant recent development in connection with common scab is its prevalence and abundance on potatoes grown on alkaline peat soils in the state. There are in northern Iowa several areas of peat soil that yield large crops of potatoes. One of these areas is at Crystal Lake, just north of Britt in Hancock

Table 1. The temperature and rainfall during twelve years when late blight of potatoes occurred in Iowa and five years when this disease was not recorded in the state. Weather records are for north central Iowa except in 1876, 1885 and 1886, which are for the state as a whole.

Year	Loss	Temperatures in degrees Fahrenheit								Rainfall in inches							
		June		July		August		September		June		July		August		September	
		Ave.	Dep.	Ave.	Dep.	Ave.	Dep.	Ave.	Dep.	Ave.	Dep.	Ave.	Dep.	Ave.	Dep.	Ave.	Dep.
1876	heavy	67.6	-2.0	74.2	-0.4	73.2	+1.1	60.4	-3.5	4.09	-0.53	6.15	+2.49	5.15	+1.58	6.42	+2.58
1885	18%	67.9	-1.7	74.6	0.0	66.9	-5.3	61.7	-2.2	5.08	+0.46	4.73	+1.07	5.90	+2.33	3.04	-0.80
1886	6%	69.3	-0.3	76.2	+1.6	74.2	+2.0	63.0	-0.9	1.73	-2.89	.50	-3.16	2.02	-1.55	4.68	+0.84
1903	considerable	64.3	-2.6	71.3	-1.2	67.3	-2.4	51.6	-10.0	2.63	-1.87	5.82	+2.27	5.28	+1.49	3.59	-0.38
1904	none	65.8	-1.1	69.5	-3.0	67.1	-2.6	62.0	+0.4	5.59	+1.09	4.09	-0.54	2.45	-1.34	2.97	-1.00
1905	1%	68.0	+1.1	69.6	-2.9	73.1	+3.4	63.6	+2.0	4.41	-0.09	2.00	-1.55	3.98	+0.19	1.61	-2.36
1915	heavy	63.3	-3.6	68.4	-4.1	65.0	-4.7	61.8	+0.2	4.93	+0.43	5.45	+1.90	2.85	-0.94	3.99	+0.02
1916	none	63.2	-3.7	78.5	+6.0	72.4	+3.7	60.7	-0.9	4.29	-0.21	2.10	-1.45	2.08	-1.71	4.70	+0.73
1917	under 1%	64.5	-2.4	72.6	+0.1	67.7	-2.0	60.5	-1.1	4.41	-0.09	4.12	+1.57	2.27	-1.52	3.76	-0.21
1918	10-20%*	68.8	+1.9	70.2	-2.3	72.3	+3.6	56.4	-5.2	4.96	+0.46	4.80	+1.25	4.42	+0.63	2.32	-1.65
1924	light	60.4	-6.5	68.5	-4.0	69.5	-0.2	57.5	-4.1	5.74	+1.24	3.57	+0.02	5.94	+2.15	3.45	-0.52
1925	under 1%	69.3	+2.4	71.9	-0.6	60.9	-8.8	67.0	+5.4	7.64	+3.14	2.31	-0.24	2.55	-1.24	6.15	+2.18
1926	none	63.8	-3.1	72.2	-0.3	71.3	+1.6	60.8	-0.8	2.50	-2.00	4.08	+0.53	3.64	-0.15	5.40	+1.43
1927	none	64.7	-2.2	68.9	-3.6	66.4	-3.3	65.1	+3.5	2.53	-1.97	1.06	-1.49	2.23	-1.56	5.10	+1.03
1928	1%	62.5	-4.4	72.6	+0.1	70.6	+0.9	58.9	-2.7	4.04	-0.46	3.69	+0.14	10.22	-6.43	2.63	-1.34
1938	none	67.6	+0.7	74.5	+2.0	73.6	+3.9	65.3	+3.7	6.18	+1.68	4.94	+1.39	2.34	-1.45	9.45	+5.48
1939	under 1%	70.2	+3.3	75.0	+2.5	69.7	0.0	67.1	+5.5	4.77	+0.27	2.40	-1.15	5.17	+1.38	0.84	-3.13

* This was restricted to Mitchell County.

County. Ninety acres of peat land in the vicinity of Crystal Lake were first cropped to potatoes in 1923, but it was not until 1916 that potato growing proved successful and profitable. Chris Gillstrap fertilized the soil and grew 350 to 500 bushels of potatoes per acre. Potato production expanded rapidly and in 1928, 20,000 bushels were pitted in addition to the many cars that were shipped out at digging time. In 1930 there were 1,500 acres in potatoes, and the yield was nearly 1,000 carloads according to the July 23, 1930, News Tribune of Britt, Iowa. Potato growing in this region has expanded more slowly during the past decade and several serious problems have developed. Among these is potato scab. Apparently these alkaline peat soils permit the scab organism to flourish so profusely that within a few years land that formerly yielded crops strikingly scab free now yields crops where every potato is scabby. The losses for the area during the last five years have exceeded 15 percent. Some fields that once were highly productive have had to be turned to other crops. Frequently following careful sorting the crop has failed to make United States grades and sold at a sharp reduction in price. Other peat soil areas in northern Iowa and southern Minnesota have had similar experiences with the common scab.

BLACK SCURF

This disease, caused by *Corticium vagum* V. & C., was reported first in 1905 (14, p. 246), but at that time it was not severe. It was reported from one county in 1907 (13) and then not again until 1918 when it was severe in Mitchell County (14, p. 246). Since 1918 (12, p. 299) this has been one of the most troublesome diseases. Losses ranging from 3 to 5 percent have been common, and in 1925, 10 percent of the crop was lost.

Black scurf occurs throughout the entire state (14, p. 246) (15, p. 121) wherever potatoes are grown. All common varieties are susceptible, although some are less so than others. Fitch (11, p. 296) claims to have observed fields in 1927 where cobblers apparently overcame the disease, while Early Ohio, even though treated with formaldehyde, did not recover. He reports that the yield of the Early Ohio was reduced 100 bushels per acre in some cases. It is questionable whether even now we sense and appreciate the loss caused by the black scurf organism. There are many strains of the organism, and it is able to attack the roots of plants other than the potato.

EARLY BLIGHT

Early blight is caused by the pathogen *Alternaria solani* (Ell. & Mart.) Jones & Grout. In 1909 Pammel (1, p. 60) reported the occurrence of early blight in 1885, although he indicated that the record was questionable. However, Pammel again recorded early blight in 1892. Greene and Maney (19) in 1910 to 1912 inclusive carried on spray experiments for the control of the early blight organism and reported good results. They probably reduced hopper injury and not early blight. Pammel in 1908 (8, p. 40) and Bliss in 1909 (9, p. 43) reported early blight as the most destructive disease of potatoes. Bliss (10, p. 45) reported potato blight in 1910 as prevalent and causing heavy losses each year. Losses of 10 and 15 percent were reported in 1910 and 1912, respectively.

It is questionable whether early blight ever was very prevalent and destructive in Iowa. At least in 1916 little or no early blight occurred in the state, and it has not occurred to any appreciable extent since that time. In 1939, however, some early blight was collected at Crystal Lake on potatoes growing on peat soils. It is quite clear now that early blight and hopper burn were confused and that the estimates given appertain largely to hopper burn.

HOPPER BURN

A disease known as hopper burn, caused by potato leaf hopper, has occurred throughout the state in destructive form every year since 1916. It frequently causes a loss of from 2 to 20 percent. Previous to 1916 this disease doubtless was confused with early blight.

BLACK LEG AND RING ROT

Black leg, caused by *Bacillus atrosepticus* Van Hall, was first reported in 1905, causing a loss of 25 percent in three counties. It was not reported again until 1918. Since that time it has been found almost every year, causing the greatest loss in 1928 when it was general and destructive on Early Ohio all over the state.

Melhus and Gilman (21) found that black leg was severest on early varieties and that it was not uncommon to find 2 to 15 percent of the potato plants killed before the crop was half mature. Archer (17, p. 24) found the disease widely distributed in 1927, especially in home gardens where the greater part of the loss occurred.

In 1939 the ring rot organism, *Bacterium sepedonicum* Spiek. & Kott., was found in the state for the first time. It causes a discoloration of the vascular ring, which in many respects resembles the symptoms of black leg. It is quite conceivable that ring rot has occurred in the state for some time and has been confused with black leg, or soft rot caused by *Bacillus carotovorus* Jones.

VIRUS DISEASES

Mosaic on potatoes in Iowa was first reported in 1918. It probably occurred much earlier because mosaic was general in all varieties grown at that time. Mosaic has occurred commonly in the state ever since, and in 1935, it caused a 12 percent reduction in the crop. Such varieties as Green Mountain and Bliss Triumph seem to be the most susceptible.

The other virus diseases that have been observed in Iowa are spindle tuber, curly dwarf, leaf roll, witches broom and calico. The two mentioned last were found for the first time in 1934.

It is a well established practice among progressive potato growers in Iowa to use certified seed stocks because of the increased yields obtained, at least during the first year. However, the high yielding capacity of certified stocks deteriorates in Iowa because of virus diseases. Tests were made at the Northern Iowa Agricultural Experimental Association Farm in 1935 to compare the yields of seed one, two and three years from certification. Cobblers and Chippewas were used for these tests. The results of these tests revealed the extent of the deterioration. The Chippewa two years from certification produced approximately a half crop, while the yield of the cobblers two years from certification was reduced 60 percent, and three years from certification the yield was reduced approximately 90 percent.

Attempts have been made to eliminate the virus diseases from home grown seed stock by indexing the same in the greenhouse during the late winter and early spring. Table 2 presents the results of tuber indexing of five varieties running through five years, 1932-1936, inclusive. The percentage of virus was somewhat reduced during the first four years but increased in the fifth, being greater in Katahdin at that time than at the beginning of the experiment. The inability of greenhouse tuber indexing to eliminate viruses under Iowa conditions may be attributed to large vector populations and the fact that vector control is not practical. While material reduction in the amount of virus was affected as compared to the original stock of 1932 it was

clear after the increase in 1936 that greenhouse indexing alone was not sufficient to make it practical to develop a virus-free seed stock under Iowa conditions.

Table 2. *Percentage of virus-diseased potatoes found by greenhouse indexing of five varieties of potatoes, 1932-36.*

Variety	Percentage of diseased tubers				
	1932*	1933	1934	1935	1936
Katahdin	61.0	47.0	43.9	40.0	73.4
Rural New Yorker..	54.0	19.2	18.0	10.9	32.2
Early Ohio	71.5	26.1	24.7	22.0	32.0
Bliss Triumph	44.2	22.5	21.3	15.0	40.0
Cobbler	65.6	42.8	35.6	32.0	46.0

*Results shown for 1932 represent the percentage of virus-diseased potatoes removed from the original seed stock.

The spread of the different viruses in the field explains clearly why certified comparatively virus-free stocks cannot be maintained in this state.

FUSARIUM DRY ROTS

There are several species of *Fusarium* that cause dry rot in storage. These organisms usually attack the potato through wounds incident to harvest and storage. *F. coeruleum* (Lib.) Sacc. and *F. eumartii* Carp. are common in the spring of the year. Another species of *Fusarium* may attack the tuber through the aerial stem and follow the stolon into the stem end of the tuber in the field before it is harvested. This organism causes a softening of the tissues, which may extend throughout the whole tuber causing a wet rot. When the invasion of the pathogen is less extensive invaded tissues dry out and impart a shrunken appearance about the stem end. It is conceivable but not definitely known that this organism also attacks the vines.

SILVER SCURF

This is a disease caused by the pathogen *Spondylocladium atrovirens* Harz, collected for the first time in the state by the senior author in 1917 on tubers of the variety Irish Cobbler. It is frequently common on potatoes held as seed stock but probably causes very slight damage.

SUMMARY

Potatoes were one of the first crops planted in Iowa. The acreage increased from 18,124 acres in 1855 to 170,285 in 1895. From then on it gradually decreased until 1930 when there were

only 44,666 acres planted in potatoes. From 1865 to 1925 the yield tendency was gradually downward and the price tendency generally upward.

Late blight was one of the earliest diseases of potatoes reported. This disease has occurred frequently but only occasionally in destructive form. Serious losses from rot occurred in 1858, 1865, 1866, 1869 and 1876, which are thought to have been caused by the late blight organism. Late blight caused losses ranging from 6 percent to heavy in 1885, 1886, 1903, 1915, 1918 and 1924. Slight damage was reported in 1905, 1917, 1925, 1928, and 1939. In years when late blight was found in the state temperatures were usually subnormal or normal and rainfall above normal during the growing season.

Common scab was first reported in 1870. It has occurred throughout the state, frequently causing crop reductions of 5 percent. In 1919, 1932 and 1934, however, losses ranged from 10 to 20 percent. During the past five years the scab organism has been very destructive in the alkaline peat soils in northern Iowa. Some fields that were once highly productive have had to be turned to other crops. Treating seed potatoes with hot formaldehyde and using certified seed have greatly reduced losses caused by scab.

Black scurf was first reported in 1905. It was severe in Mitchell County in 1918 and since that time has been very troublesome throughout the state.

Early blight has been reported as serious at various times since 1892. It is now known that this disease was confused with hopper burn. Hopper burn has been destructive throughout the state every year since 1916, resulting in annual crop reductions ranging from 2 to 20 percent.

Black leg was first reported in 1905 when it caused a 25 percent loss in three counties. It has occurred frequently since 1918. Ring rot was found in the state for the first time in 1939.

Mosaic has been common since 1918 and was unusually severe in 1935. Other virus diseases occurring in Iowa are spindle tuber, curly dwarf, leaf roll, witches broom and calico. Greenhouse indexing of tubers to eliminate viruses from home grown seed was found to be of no value in Iowa.

Several species of *Fusarium* cause dry rot of tubers in storage. Silver scurf was collected for the first time in the state in 1917.

It is common seed stock in the spring but probably causes very slight damage.

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